**Center Innovation Fund: LaRC CIF**

# Autonomous Assembly of Solar Array Modules by a Team of Robots

Completed Technology Project (2015 - 2016)

## Project Introduction

This project will investigate the hypothesis that Intelligent Precision Jigging Robots (IPJRs) and auxiliary robotic manipulators can autonomously perform the local level positioning and alignment required to enable precision assembly, disassembly, and reassembly of modular components. Key IPJR capabilities to be developed include: 1) high precision sensing and actuation; 2) state estimation using communication and simultaneous localization and mapping (SLAM); 3) robust failure detection and correction algorithms; and 4) high level artificial intelligence techniques in conjunction with low level control methods. This proposal will investigate the assembly of solar array modules to a backbone truss. The general process will use up to 6 IPJRs to grapple, precisely precision, and align a solar array module relative to a backbone truss and hold the module in place while the Lightweight Surface Manipulation System (LSMS) completes joining operations. FY16 Hardware benchmark will be a teleoperated assembly experiment that does not include simulated errors, disassembly, or reassembly. It will incorporate a SLAM algorithm for state estimation, but use high level commands given by human operators. Software benchmark will be a simulated assembly test with the following additional capabilities: disassembly by replacing step 4 with a bond cutting step, reassembly by reusing a previously disassembled solar array module, and error handling in spite of a variety of possible failures at each assembly step (such as IPJR grasp failure, IPJR deactivation, detachment of a solar panel, and failed sensors). Success will be defined by the fraction of completed trials.

## Anticipated Benefits

The IPJR paradigm will simplify assembly tasks for various missions, enabling the construction of large solar arrays, large space observatories, and large human habitats (both in space and on a planetary surface). The variety of objects that IPJRs may be able to grasp may also enable the use and assembly of ISRU components in construction. Additionally, servicing, repair, and disassembly tasks may be easier to perform with the IPJR paradigm, including performing said tasks on uncooperative spacecraft. The machine learning tasks required to perform assembly (separable into supervised, unsupervised, and reinforcement learning) have broad applicability in all robotic and autonomous tasks. In addition to assembly, the developed algorithms will have direct applicability to servicing and repair tasks, and may potentially contribute to increasing the permissible autonomy for all unmanned space missions.

Space robotic assembly will be crucial for large scale construction, including high capacity solar arrays requiring assembly and servicing, large space telescopes with apertures greater than 25 m in diameter, and servicing facilities.

The commercial space industry desires servicing capabilities to repair and refurbish spacecraft already in orbit. Advances in space robotic assembly


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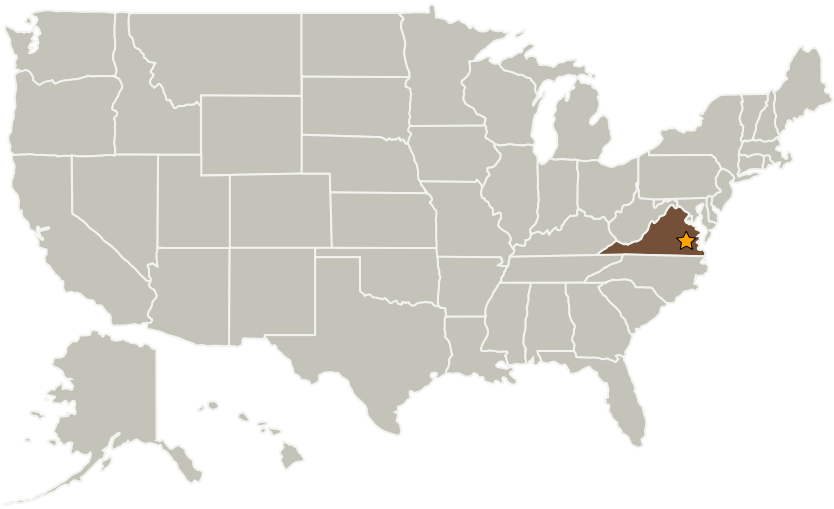
research translate to advances in servicing.

### Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Langley Research Center(LaRC) | Lead Organization | NASA Center | Hampton, Virginia |

| Primary U.S. Work Locations |
|---|
| Virginia |

### Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Langley Research Center (LaRC)

**Responsible Program:**

Center Innovation Fund: LaRC CIF

## Project Management

**Program Director:**

Michael R Lapointe

**Program Manager:**

Julie A Williams-byrd

**Principal Investigator:**

Erik E Komendera

**Co-Investigator:**

Bonnie D Allen

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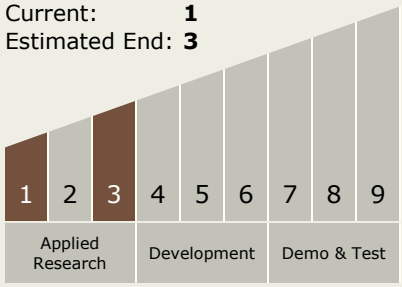
## Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **3**




## Technology Areas

**Primary:**

- TX07 Exploration Destination Systems
  - TX07.2 Mission Infrastructure, Sustainability, and Supportability
    - TX07.2.4 Micro-Gravity Construction and Assembly